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SEDIMENTATION in COLD SPRINGS RESERVOIR

Umatilla County, Oregon

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Supplementary data from
Umatilla River Watershed

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TABLE OF CONTENTS

SUMMARY AND INTRODUCTION

DESCRIPTION OF RESERVOIR WATERSHED ---------- PAGE 1
- CLIMATE ---------- 1
- GEOLOGY ---------- 1
- SOILS ---------- 2
- LAND USE CAPABILITY CLASSES ---------- 2
- HISTORY AND CONDITION OF WATERSHED ---------- 4

SEDIMENTATION SURVEY ---------- 5
- DESCRIPTION OF DAM AND RESERVOIR BASIN ---------- 5
- HISTORY OF SURVEY ---------- 8
- RESULT OF SURVEY ---------- 8

EVALUATION OF SEDIMENT DAMAGE ---------- 15
- DESCRIPTION OF IRRIGATION DEVELOPMENT ---------- 15
- EFFECT OF RESERVOIR SEDIMENT ON CROP YIELDS ---------- 17

CONSERVATION PROGRAM AND BENEFITS ---------- 18

DATA ON SEDIMENTATION IN THE UMATILLA RIVER WATERSHED ---------- 20
- DESCRIPTION OF WATERSHED ---------- 20
- SUSPENDED LOAD DATA ---------- 22
- MCKAY RESERVOIR ---------- 26

CONCLUSIONS ---------- 26

TABLES
- LAND USE BY LAND CAPABILITY CLASS - COLD SPRINGS RESERVOIR WATERSHED ---------- 3
- AREA CAPACITY TABLE - COLD SPRINGS RESERVOIR ---------- 8
- STATISTICAL SUMMARY OF SEDIMENTATION DATA - COLD SPRINGS RESERVOIR ---------- 11
- MECHANICAL ANALYSIS AND VOLUME WEIGHT OF SEDIMENT SAMPLES - COLD SPRINGS RESERVOIR ---------- 15
- SUSPENDED SEDIMENT LOAD DATA - UMATILLA RIVER AT WESTLAND BRIDGE NEAR HERMISTON, OREGON, 1951-52 ---------- 22

MAPS
- GENERALIZED SOILS - COLD SPRINGS RESERVOIR ---------- 2
- GENERALIZED LAND USE CAPABILITY CLASSIFICATION - COLD SPRINGS RESERVOIR WATERSHED ---------- 3
- RELIEF MODEL OF COLD SPRINGS RESERVOIR WHEN THE DAM WAS BUILT IN 1908 ---------- 6
- RELIEF MODEL OF RESERVOIR BASIN IN 1951 ---------- 7
- ORIGINAL TOPOGRAPHY OF RESERVOIR BASIN - 1905 ---------- 12
- TOPOGRAPHY OF RESERVOIR BASIN - 1951 ---------- 13
- A PORTION OF THE UMATILLA IRRIGATION PROJECT INCLUDING THE HERMISTON IRRIGATION DISTRICT ---------- 16
- PHYSIOGRAPHIC ZONES AND AVERAGE ANNUAL RAINFALL - UMATILLA RIVER WATERSHED ---------- 21

FIGURES
- ORIGINAL AND 1951 AREA AND CAPACITY CURVES - COLD SPRINGS RESERVOIR ---------- 9
- LONGITUDINAL PROFILES OF COLD SPRINGS RESERVOIR - 1908 AND 1951 ---------- 14
- RELATION OF THE AMOUNT OF WATER AVAILABLE FOR DIVERSION FROM THE UMATILLA RIVER TO COLD SPRINGS RESERVOIR ---------- 19
- SEDIMENT RATING CURVE - UMATILLA RIVER AT WESTLAND BRIDGE NEAR HERMISTON, OREGON ---------- 24
- FLOW DURATION CURVE - UMATILLA RIVER NEAR UMATILLA, OREGON, 1909 - 1948 ---------- 25

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SUMMARY

The Cold Springs reservoir, located in Umatilla County, Oregon, is used for the storage of irrigation water. It is located 6 miles east of Hermiston. The water supply is largely obtained by diversion from the Umatilla River. The watershed of 188 square miles, tributary to the reservoir, contributes only a small amount of water but most of the sediment. Between 1908, when the dam was completed, and 1951, sediment accumulation amounted to 5,041 acre feet, or about 10 percent of the reservoir's original storage capacity of 49,709 acre feet. About 83 percent came from the tributary watershed and the remainder from the Umatilla River by diversion canal. The loss in storage capacity has caused an average annual reduction of 6.8 percent in the supply of irrigation water. Short supplies in some years, partly engendered by sedimentation, result in a loss in crop yields.

About 75 percent of the watershed draining directly into the reservoir is in cultivation. Crops are limited to wheat in a crop-fallow rotation. Some erosion occurs on all cultivated land, the amount depending on the slope and rainfall. Land use adjustments in accordance with land capabilities and application of soil conservation practices according to the needs are recommended. These practices are designed to both substantially reduce the rate of reservoir sedimentation and maintain crop yields.

As a part of other investigations in the Columbia River Basin, the suspended sediment load in the Umatilla River was measured at Hermiston, below the Cold Springs Canal diversion, from March 31 to May 4, 1951 and from October 31, 1951 to April 26, 1952. From these data it was determined that the average annual volume of suspended sediment carried by the Umatilla River near its mouth is about 550 acre-feet per year, or 0.24 acre-feet per square mile of drainage area. A reconnaissance sedimentation survey at McKay Reservoir, on a tributary of the Umatilla River, was made in July 1946. The accumulation of sediment in this reservoir is at the rate of 13.3 acre-feet per year, or about 0.07 acre-feet per square mile of watershed.

INTRODUCTION

The sedimentation survey of Cold Springs reservoir and measurement of the suspended sediment load in the Umatilla River in northeastern Oregon were made in connection with the U. S. Department of Agriculture survey for development of the Columbia River Basin agricultural program. The Cold Springs reservoir is an off-channel storage for waters diverted from the Umatilla River. It has a tributary watershed of 188 square miles. Data from the survey provides a long record of sedimentation from a watershed that is mostly in cultivation. The survey was made at intervals during the 1951 field season. Measurements of the suspended sediment load in the Umatilla River were made below the canal diversion. A reconnaissance survey of sedimentation in McKay Reservoir on McKay Creek, a tributary of the Umatilla River, was made by the Soil Conservation Service in 1946. The results of this latter survey have not heretofore been published.

ACKNOWLEDGMENTS

The Corps of Engineers, Walla Walla District, cooperated with the Soil Conservation Service in the field survey of Cold Springs reservoir by furnishing personnel and equipment. Mr. Roy McNeil, manager of the Hermiston Irrigation District, facilitated the survey work and furnished valuable information. The West Umatilla Soil Conservation District office at Hermiston furnished personnel for the Cold Springs survey and carried out the suspended load sampling program on the Umatilla River.

DESCRIPTION of RESERVOIR WATERSHED

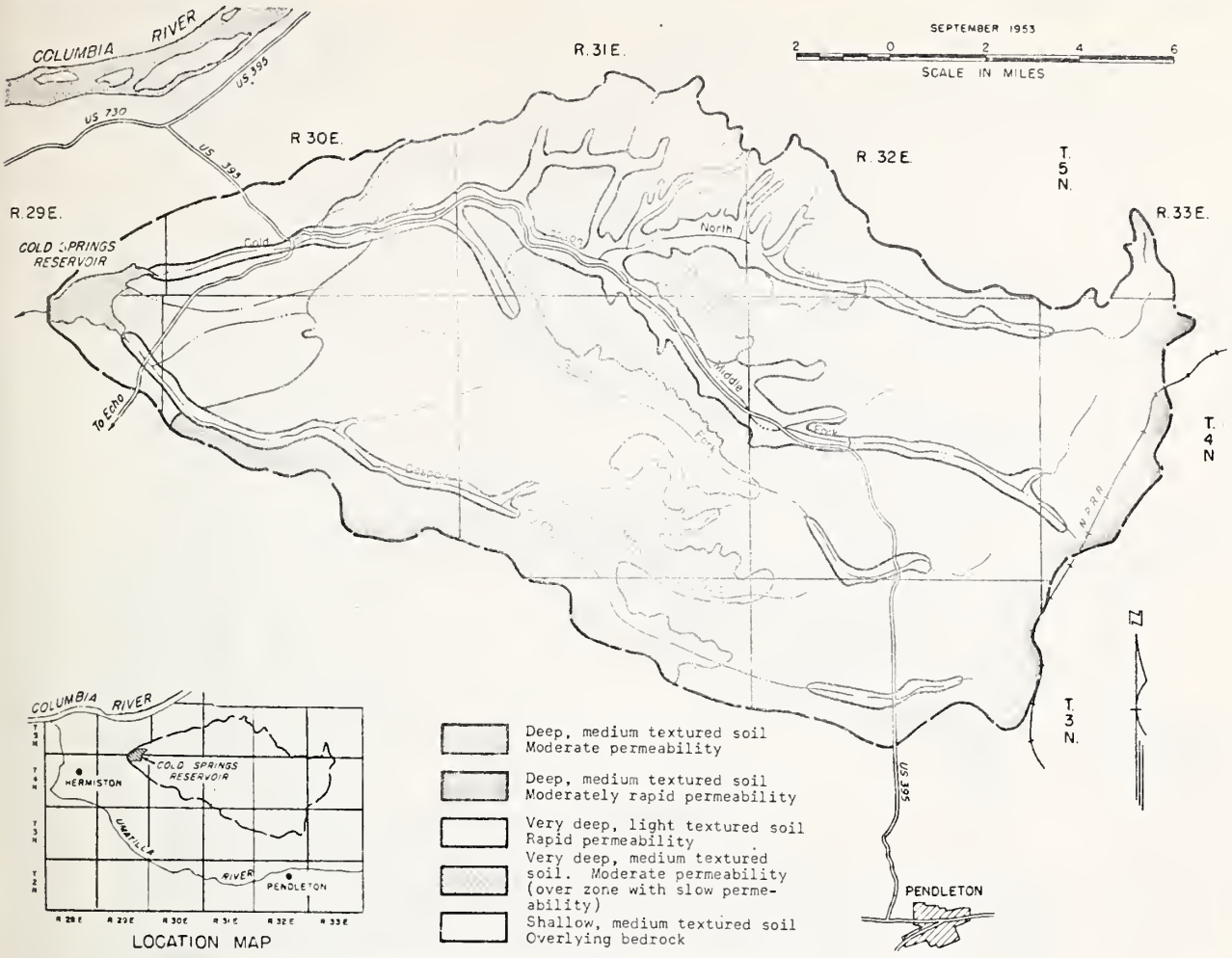
In addition to water diverted from the Umatilla River, the Cold Springs reservoir receives runoff from two streams which head east of Hermiston and north of Pendleton, Oregon. They flow west, as shown on Map 1, *page 2*, to join within the reservoir basin. The north, and main, stream is Cold Springs Canyon which has a watershed area of 126 square miles. The southern branch, Despain Gulch, has a watershed area of 62 square miles. The total drainage area, 188 square miles, is within Townships 3 - 5 North and Ranges 29 - 33 East. Length of the drainage area from east to west is about 25 miles, and the maximum width from north to south is about 13 miles. Below the dam, Cold Springs wash curves to the north and enters the Columbia River 4 miles due north of the dam.

CLIMATE

The Cold Springs reservoir watershed lies in a temperate, semi-arid region. The average precipitation at Hermiston, just west of the watershed, is about 8.3 inches annually and at Pendleton, just south of the eastern boundary, it averages about 14.2 inches annually. The differences in precipitation are due both to elevation and proximity to the Blue Mountains to the east. Seventy-six percent of the precipitation at Hermiston occurs in the months from October through March. The area is subject to occasional summer cloudbursts. The average snowfall at Hermiston is 13.6 inches per year, while the average snowfall at Pendleton is 21.4 inches. Moisture-bearing winds from the west are the general source of precipitation. The Coast and Cascade ranges, which lie between the Pacific Ocean and eastern Oregon, remove much of the moisture from these winds before they reach the Cold Springs area. Summers are warm, with humidity low and a high percentage of sunshiny days. The average annual evaporation at Cold Springs reservoir over a 6-year period amounted to 37.33 inches. Although the winters are comparatively mild, freezing temperatures occur throughout the winter months and mid-winter temperatures occasionally fall well below zero. The average length of the frost-free season at Hermiston is 174 days per year, and at Pendleton, 160 days per year. Prevailing direction of the wind is from the southwest. Average wind velocity is more than 6 miles per hour with steady winds of considerably greater velocity occurring for days at a time. Located in the valley cut by the Columbia River, the Hermiston area is open to the strong winds through the gorge and Cascade Mountains to the west.

GEOLOGY

The Cold Springs watershed is located in the Columbia Plateaus physiographic province and lies just west of the Blue Mountain section. It is of gently rolling to hilly topography with the steepest slopes and greatest relief along the northern divide. This rolling to hilly plateau ascends from 620 feet above sea level at the dam to about 1,900 feet at the eastern divide. Maximum difference in elevation between the stream and the adjacent divide is about 450 feet. The area is underlain by Columbia basalt, which slopes northwest from the Blue Mountains, and consists of layered flows of lava. The basaltic lava was extruded during Miocene time. It is dense and dark gray, brown or black.



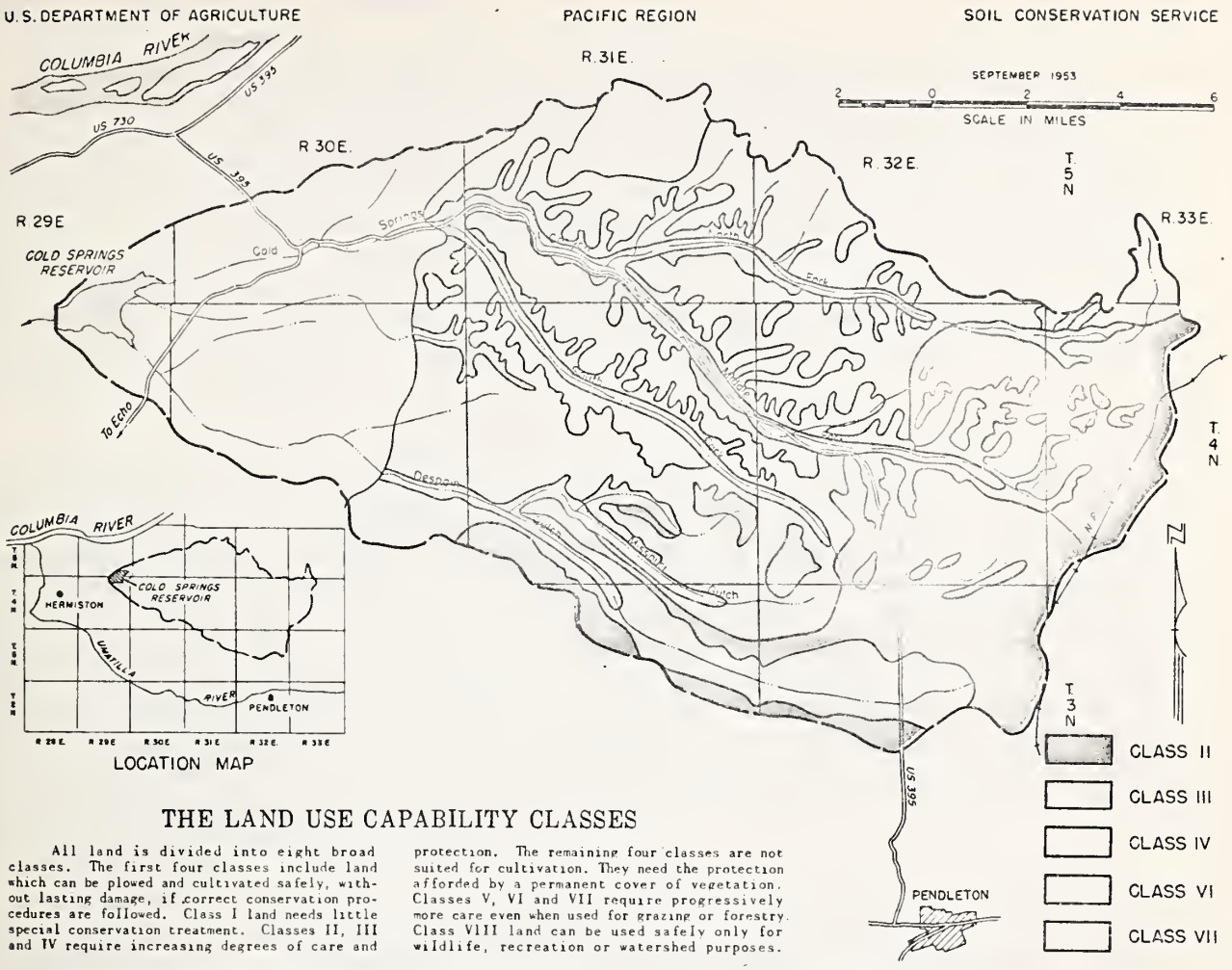
Map 1. Generalized soils, Cold Springs Reservoir Watershed.

SOILS

The overlying soil mantle on the western edge of the watershed consists of old river terrace deposits. These soils are very deep, light to medium textured and with high permeability. Soils in the middle and upper reaches are of loessal origin, and mantle the underlying basalt to depths reaching 100 feet. These soils are of medium texture, and with moderate to high permeability. The streams have cut down through these deposits and into the basalt, forming narrow valleys, which have thin or rocky soils on the side slopes. The streams are flowing generally on bedrock. Map 1 is a generalized soils map of the watershed.

LAND USE CAPABILITY CLASSES

Table 1 gives present land use, by land capability class, of the Cold Springs watershed. The chief limiting factors affecting capability of the lands in this watershed are erosion and climate. The lower and upper ends of the watershed have gentle slopes. The favorable moisture conditions, combined with gentle slope, place much of the area in the upper watershed in land capability Class II. The central portion of the watershed, with slopes ranging from 8 to 40 percent and with moisture conditions only moderately



THE LAND USE CAPABILITY CLASSES

All land is divided into eight broad classes. The first four classes include land which can be plowed and cultivated safely, without lasting damage, if correct conservation procedures are followed. Class I land needs little special conservation treatment. Classes II, III and IV require increasing degrees of care and protection. The remaining four classes are not suited for cultivation. They need the protection afforded by a permanent cover of vegetation. Classes V, VI and VII require progressively more care even when used for grazing or forestry. Class VIII land can be used safely only for wildlife, recreation or watershed purposes.

Map 2. Generalized Land Use Capability Classification; Cold Springs Reservoir Watershed

favorable, are chiefly in capability Classes III and IV. The lower end of the watershed, which is of lower relief and moderate slope, has extremely droughty soils and less than 10 inches precipitation. In this area with little or no runoff, the chief problem is not one of water erosion, which is the most significant type of erosion in the rest of the watershed, but wind erosion. The steady winds from the southwest blow the sandy soils in the lower end of the watershed into dune topography, which is evidenced in the original topography of the reservoir basin. For illustration see the photograph of the model, Map 3, *page 6*. With low precipitation, high susceptibility to wind erosion and droughty condition, the soils in this part of the area are in land capability Class VII. Map 2 shows the generalized capability classes of land in the Cold Springs watershed.

LAND USE	CAPABILITY CLASSES				
	II ACRES	III ACRES	IV ACRES	VI ACRES	VII ACRES
WHEAT-SUMMER FALLOW	24,032	53,082	9,050	1,415	2,535
RANGE AND WASTE			3,878	3,302	22,815
	24,032	53,082	12,928	4,717	25,350
PERCENT	20	44	11	4	21

Table 1. Land Use by Land Capability Class, Cold Springs Reservoir Watershed.

HISTORY AND CONDITION OF WATERSHED

The first principal agricultural use of the Umatilla County area, of which this watershed is a part, was the raising of cattle, horses and sheep. Such enterprises began in the early 1870's. Native vegetation consisted of climax stands of bunchgrass and browse. Some wheat was grown in the area about 1870, but the greatest expansion in grain growing started between 1876 and 1900. Almost 80% of the Cold Springs watershed is now in fall seeded winter wheat and fallow. The average wheat yield is between 20 and 30 bushels. Cattle and sheep find late winter and early spring grazing along the steep sides of the valleys, where the soils are thin, and in arid lower portions of the watershed. Cheat grass, remnants of the original bunchgrass and sage are predominant plant species.

The land is in fallow every other year for the conservation of moisture. Until recent years few practices for conservation of the soil had been applied. Utilization of stubble mulch is about the only extensively applied conservation measure, being practiced on about 20% of the farms. The volume of organic matter in the soil is steadily decreasing, thereby increasing vulnerability to erosion. The area is most susceptible to erosion during the winter months, usually in January or February. The periods of most serious erosion losses are usually preceded by moist, cold weather in the late fall or early winter when the soils freeze. Frequently, subsequent snowfall accumulates. Then warm winds, known as "chinooks" and sometimes accompanied by rain, rapidly melt the snow and frost in the upper soil layer. Frost below the thawed layer prevents percolation and most of the water runs off, carrying a layer of surface soil with it.

One of the worst periods of erosion on record in this area occurred in February 1949. A description of climatic conditions at that time will serve to illustrate the combination of events which frequently cause severe soil losses.

Moistened by fall rains, soils became frozen by the middle of December 1948. January was an unusually cold and dry month with the average temperature 16.8 degrees, or 14.8 degrees below normal at the Pendleton airport near the southeast boundary of the watershed. As a result of extremely low temperatures and light snowfall, the soils became frozen to depths of 15 to 30 inches. Temperatures up to 57 degrees on the 10th of February took the frost out of the top 2 to 6 inches of soil. On February 18 and 19 an inch of precipitation occurred, mostly as sleet and snow. Through this period only slight to moderate erosion had occurred. On February 21-22, .27 inch of rainfall occurred, accompanied by chinook winds and temperatures up to 54 degrees. Melting snow water combined with the rainfall on the saturated soil mass overlying the frozen soil layer to create the severe erosion conditions. According to changes in the staff gage at the dam, 10,987 acre-feet of water entered the reservoir during the period from February 10 to February 28. An additional 590 acre-feet entered the reservoir from the tributary watershed on March 10.

Records show that the runoff during 1949 and 1950 yielded by far the most water and probably the most sediment of any years during the period 1927-1950. Runoff during the period February 10 to March 10, 1949 slightly exceeded the runoff during a like period in 1950. In 1950, however, 10,842 acre-feet of

water came into the reservoir in one day. That was February 10, 1950. There was no significant inflow in 12 of the 23 years.

Average annual soil loss on the Cold Springs watershed ranges from perhaps 5 to 10 tons per acre to a very small fraction of a ton per acre. The difference in precipitation probably accounts in large measure for this variation. But during the 1949 runoff period, soil losses were up to 50 tons per acre. Where steeper and longer slopes occur in zones of higher precipitation, soil losses were much greater. A few miles to the east, toward the Blue Mountains, soil losses up to 200 tons per acre occurred.

Data from the Pullman area, in the Palouse country of eastern Washington, indicates that only about 25 percent of the soil eroded from the fields in that area is carried to a downstream measuring point such as a reservoir or sampling station. The remainder is deposited on colluvial slopes, in road ditches and along the narrow flood plains.

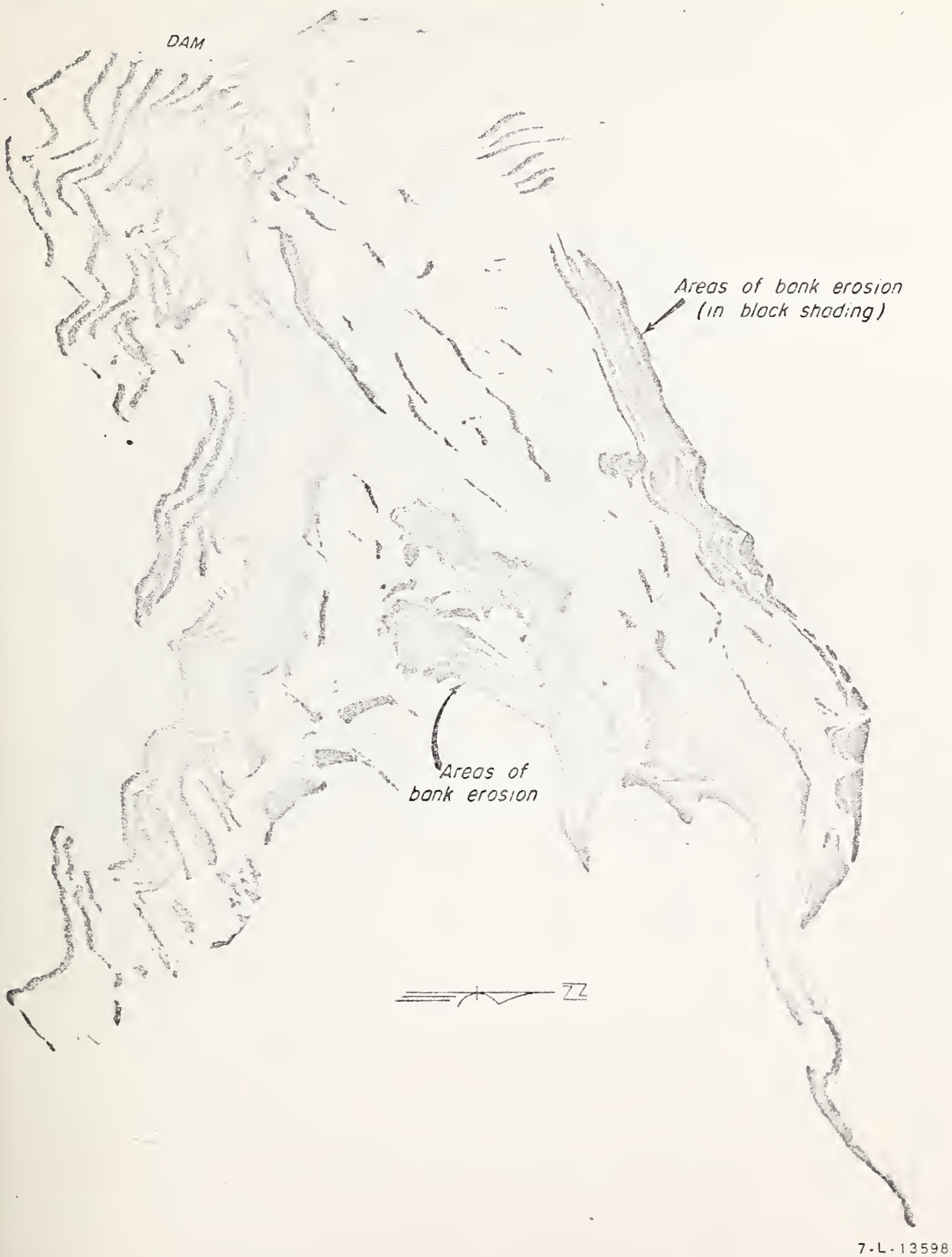
Erosion is most severe on fields in fall seeded wheat. A relatively well pulverized seed bed is prepared in the fall. When erosion producing conditions occur the grain usually has not developed sufficiently to function as a protective cover. There is also less water storage capacity available in the moist soil under a seedling wheat crop than in land in stubble. Land left in stubble or stubble mulched fallow is usually well protected, except for old erosion scars left from the preceding year when the field was in grain.

In the Cold Springs watershed, sheet and rill erosion are prevalent, but gully erosion has as yet played a minor role.

SEDIMENTATION SURVEY

DESCRIPTION OF DAM AND RESERVOIR BASIN

Cold Springs dam is located 6 miles east of Hermiston, Oregon, in Sec. 3, T. 4 N., R. 29 E. Construction was begun by the Bureau of Reclamation in 1906 and the first water was turned into the reservoir on February 5, 1908. The reservoir was designed as an off-channel storage for water diverted from the Umatilla River at Echo, which is about 7 air miles southeast of Hermiston. The dam is an earth fill structure with concrete core, 3,450 feet in length and 85 feet in maximum height above the stream bed. The base is 460 feet in maximum thickness, and the crest is 20 feet in width. Placed basalt rock faces the dam both on the upstream and downstream sides. Total volume of the dam is 793,400 cu. yds. The elevation of the crest is 631.18 feet above mean sea level. A spillway located at the north end of the dam consists of a concrete sill over rock outcrop and is 330 feet in width. The maximum water surface allowed is at 621.5 feet, although a curb of about 1½ feet extends above that elevation. The reason for keeping the maximum water surface at 621.5 is that, some years ago, a high wind occurred when the lake level was higher and the waves splashed over the crest of the dam. Since then it has been considered unsafe to permit storage beyond the 621.5 foot level. The spillway is reported never to have been used, although a photograph taken in April 1912 shows a thin film of water flowing down the chute below the spillway crest. Two outlet gates, 4 x 6 feet in dimension, are at elevation 560 feet. They are controlled from a tower located midway in the dam near the old streambed.



Map 3. Relief model of Cold Springs Reservoir when the dam was built in 1908. Areas in black on the north and east sides of the reservoir indicate land lost by bank erosion between 1908 and 1951.

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Map 4. Relief model of the reservoir basin in 1951 after deposits from the two tributaries had formed a large delta. Sediment brought in from the Umatilla River by the diversion canal has created a small delta near the dam.

The reservoir consists of a broad lower and middle basin splitting into two arms. One is the Cold Springs Canyon arm, or north tributary; the other is the Despain Gulch arm, or south tributary. The average width of the middle and lower basin is about 5,500 feet. Its maximum length from the dam to the head of the Cold Springs Canyon arm is about 3.3 miles, and about 2.6 miles to the head of Despain Gulch arm. The original surface area of the reservoir was 1,540 acres and the storage capacity, 49,709 acre-feet.

Fluctuating water levels and favorable conditions for growth have permitted willows to gain a foothold around the sides of the reservoir, particularly on the south and at the heads of the two deltas. These areas being shallower, they are more frequently exposed. Experimental data in other parts of the West have shown that phreatophytes, such as willows, use a large amount of water that would otherwise be available for irrigation or other uses.

HISTORY OF SURVEY

The first field work in connection with the Cold Springs reservoir survey was done in the spring of 1951, when engineers established control points for a tie-in with a 1905 topographic survey. Following this, and in May, 1951, a four-man survey party used the control points in sounding the reservoir. Intersection of angles from two transits located the soundings. Communications between the boat and shore were maintained by a 3-way radio hookup. Elevations in the upper deltas were completed in the fall of 1951, after withdrawal of water for irrigation. A new map was prepared on the basis of the data obtained, and minor adjustments were made in the 1905 survey map. The capacity tables, computed from both the surveys by the modified prismoidal formula on page 163 of USDA Technical Bulletin 524 "Silting of Reservoirs", are given in Table 2. Capacity and area curves also developed from the calculations are shown on Figure 1.

Contour	Original Area Acres	1951 Area Acres	Original Storage Capacity Acre-Feet	1951 Storage Capacity Acre-Feet
545	9		38	
550	22		114	
555	69	5	330	2
560	141	33	845	69
565	236	176	1,780	545
570	368	298	3,281	1,717
575	487	400	5,417	3,458
580	563	485	8,045	5,672
585	653	564	11,089	8,298
590	757	673	14,619	11,394
595	874	782	18,701	15,008
600	981	877	23,343	19,162
605	1,072	994	28,483	23,846
610	1,198	1,149	34,166	29,208
615	1,311	1,324	40,449	35,397
620	1,483	1,478	47,443	42,412
621.5	1,540	1,530	49,709	44,668
625	1,667	1,654	55,328	50,254

Table 2. Area Capacity Table, Cold Springs Reservoir.

RESULTS OF SURVEY

The sedimentation survey shows that 5,041 acre-feet of sediment accumulated in the reservoir during a period of 43 years since the dam was built. The average rate of sedimentation is 116.6 acre-feet per year. This volume

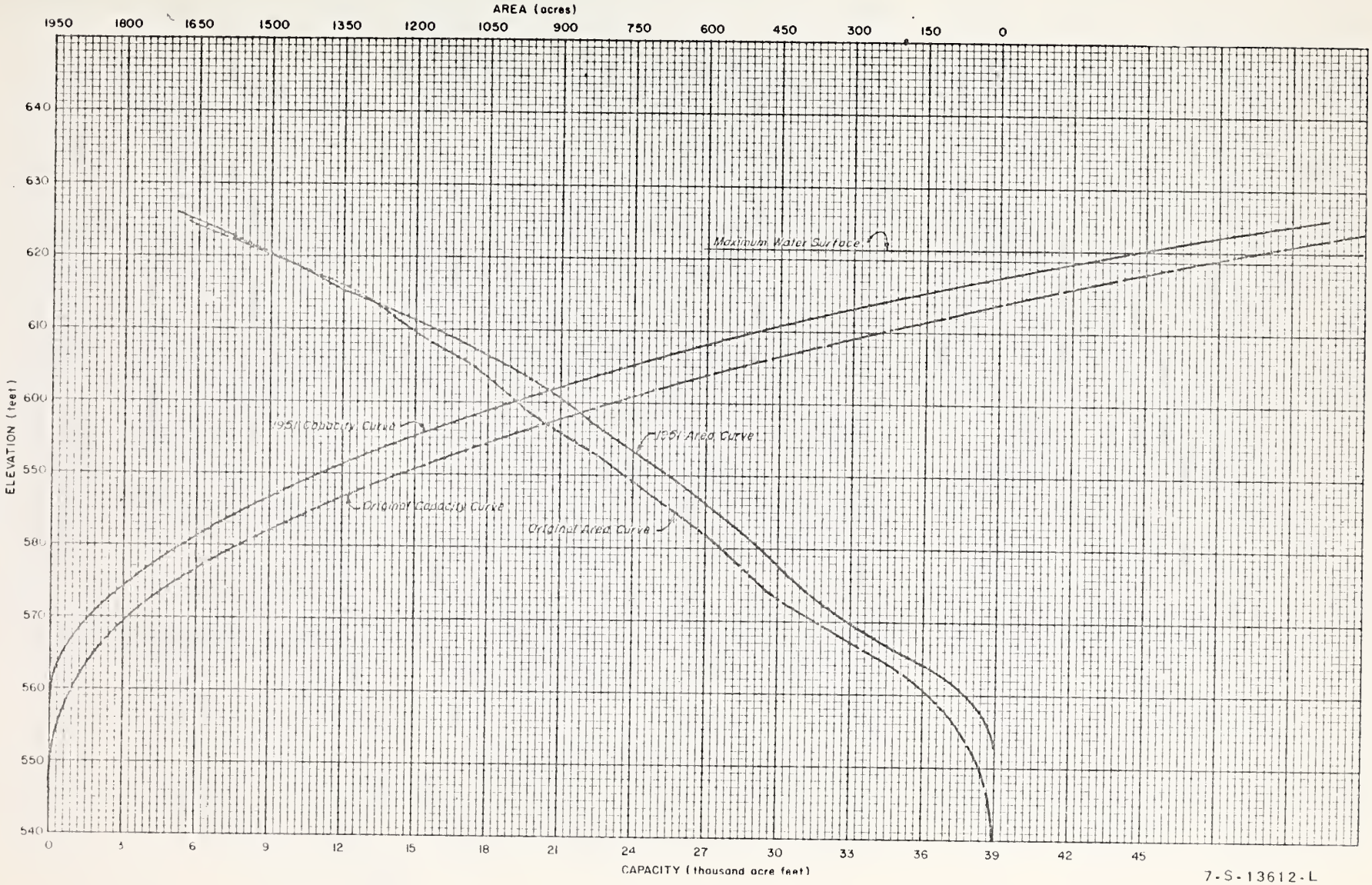


Figure 1. Original and 1951 area and capacity curves, Cold Springs Reservoir.

includes, in addition to the contribution from the tributary watersheds, a certain amount of sediment entering the reservoir basin with the diverted streamflow of the Umatilla River. In order to determine the rate of sedimentation from the tributary watershed, it was desirable to attempt a separation of deposits from this source and from the Umatilla River. Models prepared from maps of the 1905 and 1951 surveys, Maps 3 and 4, *pages 6 and 7*, show that the delta deposits from the tributary watersheds extend down to the closure of the 565-foot contour. It can also be seen that a small delta has formed at the mouth of the diversion canal. A separate calculation showed that the delta deposits from the local watersheds, exclusive of deposits above the maximum water level, consisted of 3,510 acre-feet and that the volume of the sediment in the delta at the mouth of the canal was about 105 acre-feet. A part of the latter delta resulted from enlargement of the canal entrance below a concrete overfall. The remaining 1,426 acre-feet consist of a mixture of both tributary watershed and canal deposits. An unmeasured quantity of sediment has become lodged above the maximum water level. This quantity is believed to be comparatively small, since the valleys are narrow in this area. It is estimated to be between 200 and 300 acre-feet.

Diversion of the Umatilla River water near Echo is accomplished by a diversion dam 3 feet high and 400 feet long. The canal takes off at right angles to the direction of the river at this point, and the flow into the canal is controlled by 8 gates, each 2 x 6 feet. The canal between the river diversion and the reservoir is about 24 miles long and is subject to sedimentation, particularly in the big bend in the canal northwest of the town of Stanfield. The average annual cost to the irrigation district of removing sediment from the canal is about $1,500. A study of the relation between discharge and sediment concentration at the Hermiston sampling station was made. This showed that the probable maximum amount of sediment which could have been diverted from the river into the canal, during the more than 43 years since construction of the reservoir, amounts to about 1,100 acre-feet. It is expected that the concentration of sediment in the canal is less than in the river, due to the right-angle diversion, and also that some significant deposition occurs in the canal before the water reaches the reservoir. Then too, operation of the reservoir outlet gates near the canal entrance permits some sediment to go through the reservoir without deposition. In view of these several factors, it is anticipated that the total amount of sediment deposited from the canal must be considerably less than that estimated from the computed sediment concentrations in diverted water.

It is estimated that not more than half of the 1,426 acre-feet of sediment deposits below the 575-foot contour came from the canal. Since the sandy river terrace soils in the lower watershed are not a significant source of sediment, the remaining 4,328 acre-feet of sediment in the reservoir, less about 125 acre-feet caused by wave erosion above maximum water level, came from only about 148 square miles of the tributary watershed. The rate per square mile per year from the net contributing area is about 0.66 acre-feet. Results of the sedimentation survey are summarized in the statistical summary, Table 3. The original (1905) and 1951 contour surveys are shown on Maps 5 and 6, *pages 12 and 13*.

An unusual and interesting feature revealed by the Cold Springs reservoir survey is the fact that a large segment of the basin is subject to wave erosion. Due to the fluctuation of the water level in the reservoir, the effects of wave erosion have been felt at all levels. An inspection of the models of

ITEM	QUANTITY	UNIT
AGE 1/	43.25	YRS.
DRAINAGE AREA 2/	187.7	SQ. MI.
RESERVOIR		
AREA AT MAXIMUM STAGE, 3/ ORIGINAL	1540	ACRES
AREA AT MAXIMUM STAGE, 3/ 1951	1530	ACRES
ORIGINAL STORAGE CAPACITY	49.709	AC. FT.
PRESENT STORAGE CAPACITY	44,668	AC. FT.
ORIGINAL STORAGE CAPACITY PER SQ. MI. OF DRAINAGE AREA	264.8	AC. FT.
PRESENT STORAGE CAPACITY PER SQ. MI. OF DRAINAGE AREA	238.0	AC. FT.
SEDIMENTATION		
TOTAL SEDIMENT	5,041	AC. FT
ACCUMULATION PER YEAR, AVERAGE	116.6	AC. FT.
TOTAL APPROXIMATE SEDIMENT DEPOSITED FROM TRIBUTARY WATERSHED	4,200	AC. FT.
AVERAGE ANNUAL APPROXIMATE SEDIMENT ACCUMULATION FROM TRIBUTARY WATERSHED	97.1	AC. FT.
ANNUAL SEDIMENT ACCUMULATION PER SQUARE MILE OF TRIBUTARY WATERSHED	0.52	AC. FT.
ANNUAL SEDIMENT ACCUMULATION PER SQUARE MILE OF CONTRIBUTING WATERSHED 4/	0.66	AC. FT.
ANNUAL SEDIMENT ACCUMULATION PER ACRE OF CONTRIBUTING WATERSHED		
BY VOLUME	47	CU. FT.
BY WEIGHT 5/	1.83	TONS
DEPLETION OF STORAGE		
LOSS OF ORIGINAL CAPACITY PER YEAR	0.24	PERCENT
LOSS OF ORIGINAL CAPACITY TO DATE OF SURVEY	10.14	PERCENT

1/ WATER FIRST ENTERED RESERVOIR BY DIVERSION FROM UMATILLA RIVER ON FEBRUARY 5, 1908. DATE OF THIS SURVEY, MAY 1951.

2/ EXCLUDES RESERVOIR AREA.

3/ ELEVATION 621.5 FEET ABOVE SEA LEVEL.

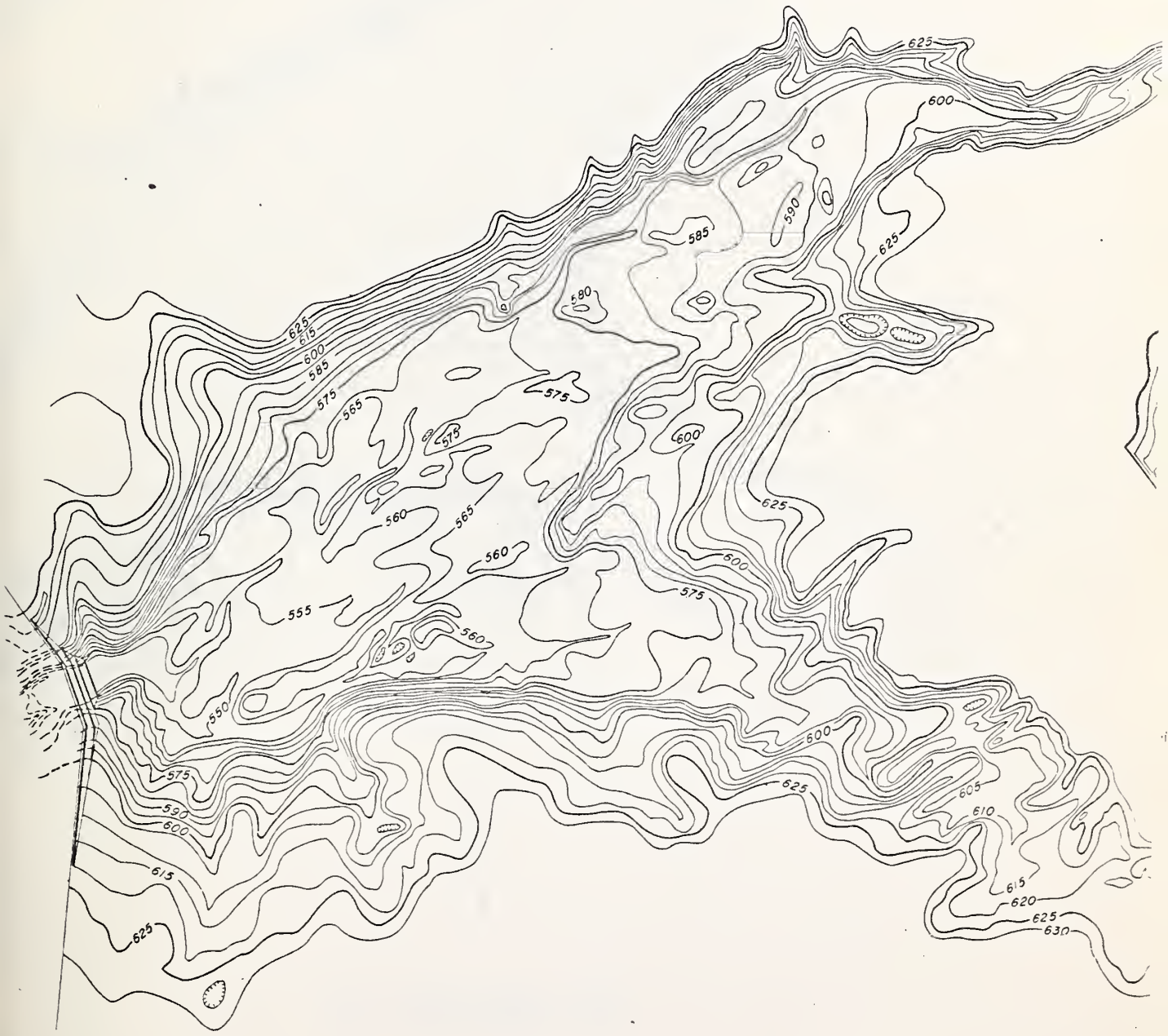
4/ ONLY 148 SQUARE MILES IS SEDIMENT CONTRIBUTING.

5/ AVERAGE WEIGHT AT 78 POUNDS PER CUBIC FOOT.

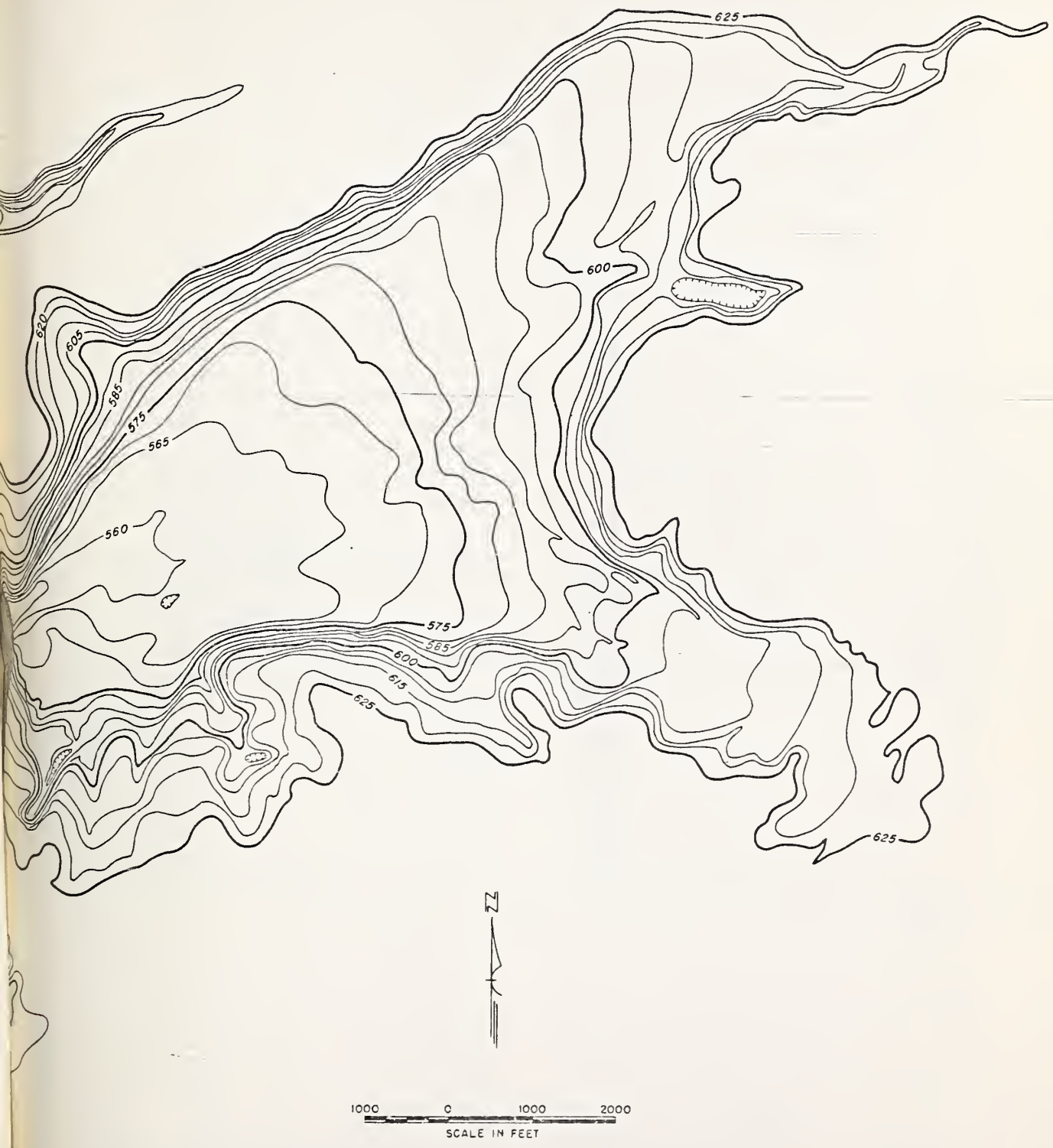
Table 3. Statistical Summary of Sedimentation Data, Cold Springs Reservoir.

the reservoir basin as it was originally, and in 1951, Maps 3 and 4, *pages 6 and 7*, shows the extent of the land loss that has occurred along the north and east sides of the reservoir. The east end of the reservoir in particular was subject to wave action because of the long fetch of the wind. Peninsulas and other promontories have been erased and some of the coves have almost lost their identity. The unconsolidated soil material exposed to wave action was one of the major reasons for the extent of the phenomenon; another was the prevalence of high and continuous winds in this area. At one place, at elevation 575 feet, the contour has been pushed back about 1,000 feet. Soil material from about 167 acres of land within and adjacent to the reservoir has been moved from its original position by wave erosion. The amount of sediment involved in this movement is 500 or 600 acre-feet. The area of bank cutting at crest elevation is about 20 acres and lands originally 10 or more feet above that level are now being engulfed. Some of the wave-cut cliffs are almost 20 feet in height. It is estimated that the total amount of sediment brought into the reservoir from beyond the spillway level by wave erosion is about 125 acre-feet.

Profiles through the bottom of the reservoir, Figure 2, *page 14*, show that the deposits range in thickness from about 10 feet near the dam to little or no deposition at the 565-foot level, and some 20 feet in the lower section of the delta. Much of the deposit has had some redistribution by current and wave action following drawdown of the water level. The average maximum drawdown is in the vicinity of the 565-foot contour closure. If sediment was deposited in this area, it was subsequently washed down.



Map 5. Original topography of reservoir basin mapped in 1905.



Map 6. Topography of reservoir basin in 1951 after deposition of more than 5000 acre-feet of sediment.

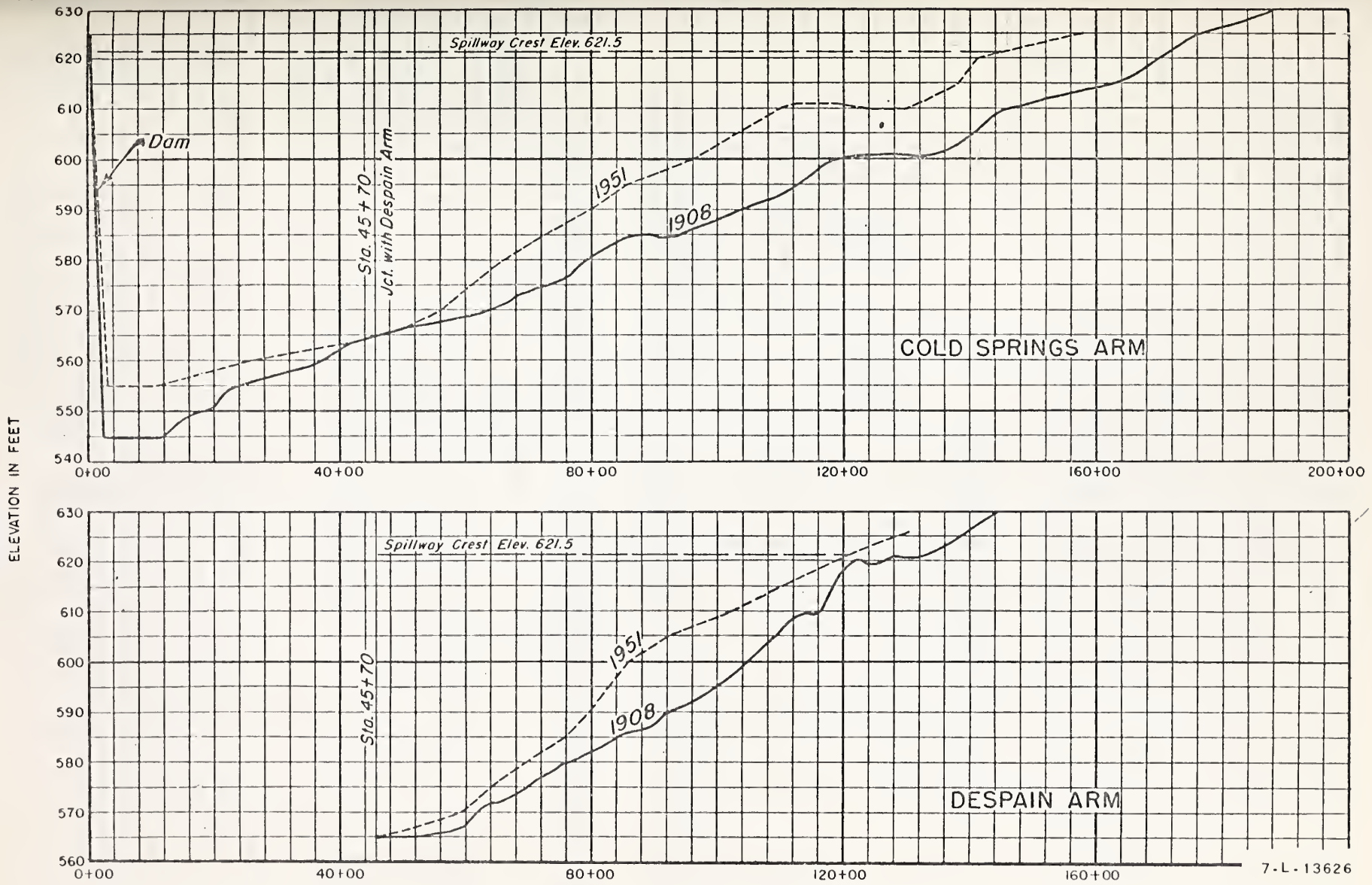


Figure 2. Longitudinal profiles of Cold Springs Reservoir in 1908 and 1951. Maximum depths of sediment are in the delta region of both tributary arms.

During a period when the reservoir was almost dry a series of eight undisturbed samples of the sediment were obtained. A description of their location, mechanical analysis and volume weight are given in Table 4. The analysis shows that, on the average, the deposits contain 4 percent medium and 33 percent fine sand, 44 percent silt and 19 percent clay. The common pattern in reservoirs, of distribution by size from fine fractions near the dam to the coarser ones in the upper end, is present at Cold Springs reservoir. The sample taken of the canal delta deposits are fine-textured, as may be expected, partially because of the opportunity for deposition of sand along the canal. At least a part of the sand showing up in the samples near the head of the reservoir must be from the sand banks that are being cut by wave erosion. Annual withdrawal of water from the reservoir has led to compaction of the deposits. The average volume weight is thus relatively high, or about 78 pounds per cubic foot.

	Medium Sand % 1/	Fine Sand % 2/	Silt % 2/	Clay % 2/	Vol.Wt.Lb./Cu.Ft.
Delta of Diversion Canal	0	11	71	18	64
Lower Reservoir North Side	0	16	31	53	70
Lower Cold Springs Canyon Delta	1	53	31	15	77
Middle Cold Springs Canyon Delta	0	16	66	18	66
Upper Cold Springs Canyon Delta	1	43	42	14	72
Lower Despain Gulch Delta	2	37	47	14	82
Middle Despain Gulch Delta	14	20	52	14	92
Upper Despain Gulch Delta	11	70	8	11	101
Average	4	33	44	19	78

1/ Caught By 60 Mesh Screen 2/ Hydrometer Determination

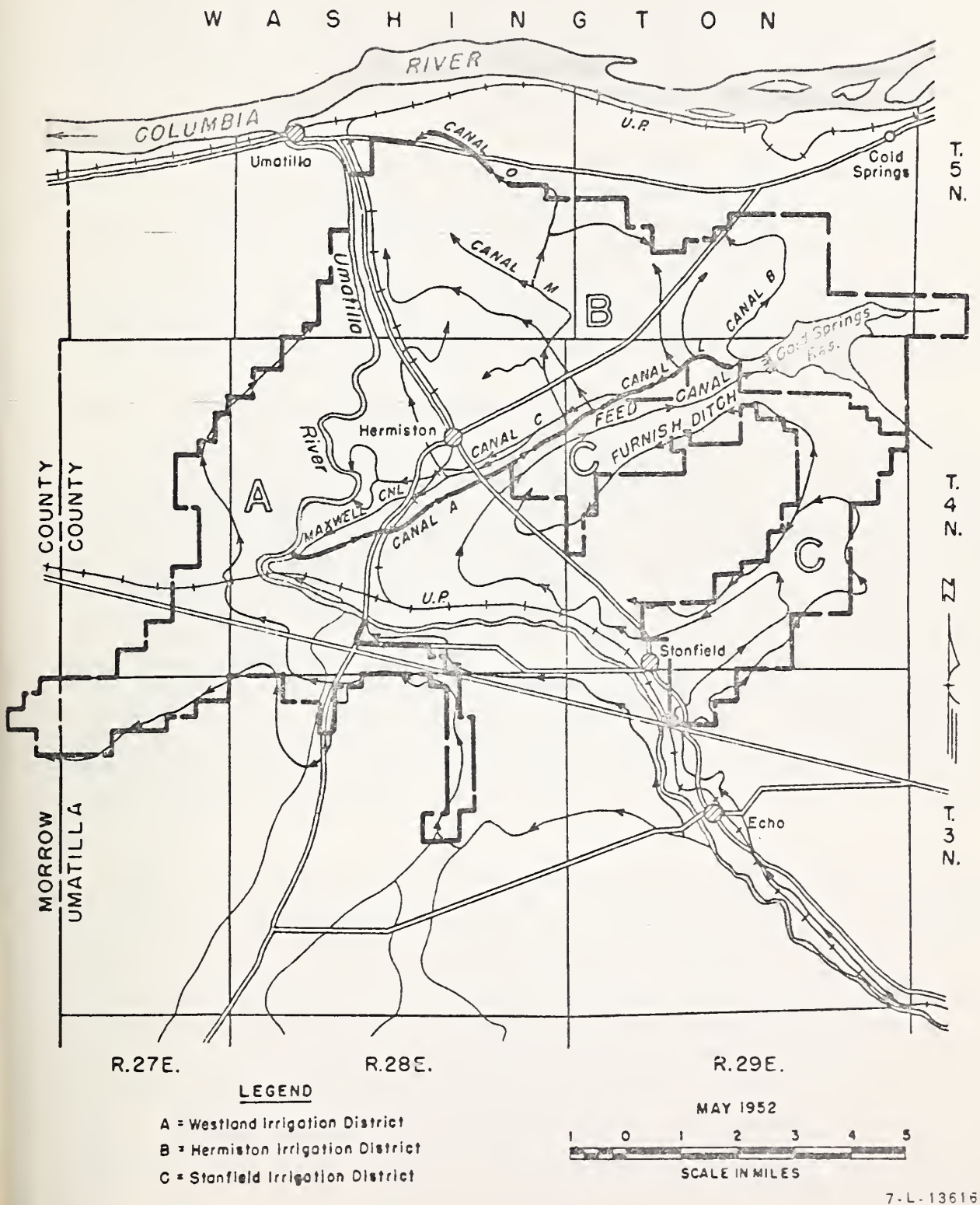
Table 4. Mechanical analysis and volume weight of sediment samples, Cold Springs Reservoir.

EVALUATION of SEDIMENT DAMAGE

DESCRIPTION OF IRRIGATION DEVELOPMENT

The Cold Springs reservoir is a part of a system for irrigating land around, and largely north and east of, Hermiston. It is known as the Hermiston Irrigation District or East Division, Umatilla Project. Map 7, *page 16*, shows the location of this district in relation to the Stanfield and Westland Irrigation Districts which, together, are known as the South Division, Umatilla Project. They obtain water from the McKay Reservoir. Another irrigation district west along the Columbia River obtains water by direct diversion from the Umatilla River.

Water was first available for irrigation from Cold Springs reservoir on March 8, 1908. Over a period of years, an average of 7,319 acres has been irrigated by water from the reservoir and from a direct river diversion known as the Maxwell Canal. The Hermiston Irrigation District has the right to divert all the water it needs from the Umatilla River between October 15 and April 15. Between April 15 and October 15, it can take only the flood flows above 400 cubic feet per second. The diversion canal carries about 225 feet per second at the point of diversion and delivers about 200 cubic feet per second at maximum capacity to the reservoir. The remainder is lost in seepage and evaporation enroute.



Map 7. A portion of the Umatilla Irrigation Project including the Hermiston Irrigation District served by Cold Springs Reservoir.

The soils of the irrigated area are deep, highly permeable sands which originally had, and to a considerable degree still have, micro-relief due to shifting by winds. Because of the droughty soil and need for additional leveling and improved water application, the duty of water is 6-7 feet per season when sufficient water is available. In 1950 about 91% of the acreage was used for the production of hay and forage, about 6% for cereals, and the remaining 3% for vegetables and truck, fruits and nuts and hops. The average yield of alfalfa in 1950 was 2.8 tons per acre and corn 65.8 bushels per acre. The yield of pasture forage was not computed but was valued at $16.63 per acre.

The West Umatilla Soil Conservation District, which embraces 214,502 acres of irrigated and range land, was organized in the area in 1946. Soil and water conservation measures advocated by the district are designed to increase the efficiency of water use, as well as to maintain yields and protect the land from wind and water erosion. Some of the more popular measures now being applied in this district are land leveling, cover cropping and the seeding of grasses and legumes in crop rotations and pasture. Only the west edge of the soil conservation district is within the Cold Springs watershed.

EFFECT OF RESERVOIR SEDIMENT ON CROP YIELDS

An evaluation was made to determine what effect, if any, the sediment volume of 5,041 acre-feet in the Cold Springs reservoir has on the economy of the irrigation district. During the period from 1928 to 1949, an average of 72,000 acre-feet per year were diverted from the Umatilla River into the Cold Springs canal. There is sufficient water available from the river to fill the reservoir by late March or early April. At about the same time as the reservoir becomes filled, water is withdrawn for spring irrigation. In good runoff years, all or most of the water being withdrawn is replaced by new water diverted from the Umatilla River during the months of April, May and June. In low runoff years, the demand for water during April, May and June greatly exceeds the amount replaced by canal diversion. An examination of the records of reservoir drawdown shows that, in general, a minimum of water remains in the reservoir at the end of the irrigation season during the drier years. A pool of water is usually left in the reservoir above the outlet gates to maintain fish life.

The relationship between the amount of replacement water available for diversion to the reservoir in April, May and June and the availability of water for irrigation during the months of July, August and September is shown in Figure 3, *page 19*. When this relationship was established the records of the Bureau of Reclamation were studied to determine whether the yield of crops was affected by a shortage of water during the latter part of the seasons when the supply of water was less than average. Alfalfa is the only crop of importance in terms of acreage where data on yields are available. A statistical analysis was made of the relationship between the amount of water delivered to farms in July, August and September and the average yield of alfalfa for the entire season. The coefficient of correlation between the two sets of data is 0.483 which indicates significance to the 5 percent level. In other words, increased water delivery results in increased yield of alfalfa about 95 percent of the time. The range in average yields is from 2.1 to 2.9 tons per acre per season and the range in amount of water applied during July, August and September is from 2.08 to 3.81 feet.

The dead storage below the outlet gate at elevation 560 originally amounted to 845 acre-feet. Sedimentation has reduced this storage to 69 acre feet, so that future accumulation will displace only usable storage, either for irrigation above the usual minimum drawdown to about elevation 564 or for preservation of fish life. The 5,041 acre-feet of reservoir sediment, therefore, now displaces about 3,055 acre-feet of water delivered to farms after deducting for transmission losses. This volume is the equivalent of 0.4 acre feet per acre of delivered irrigation water per year.

The average annual delivery of water to farms for 17 years has been 5.87 acre-feet per acre. The 0.4 acre-foot of water now displaced by sediment is 6.8% of the average annual delivery. In the driest year of available record, 0.4 acre-foot per acre was equivalent to 8.2% of the total application, and during the year of most abundant application it was equivalent to 5.4%.

The total gross value of crops in the Hermiston Irrigation District, or East Division Umatilla Project in 1950 was $281,220. If the reduction in yield of all crops was in direct ratio to the reduction in average annual application of water, the loss in gross value of crops due to sedimentation would amount to about $19,000 at 1950 values. The low efficiency of water application in the Hermiston area and other factors, however, make it unlikely that a direct ratio between water application and yield does exist. Improvements in efficiency of water use would probably outweigh the reduction in supply due to sedimentation in many seasons. If sedimentation continues at the same rate in the future as in the past, another 43 years will show a loss in water at least double the present day loss. In years of extreme water shortage, several thousand acre-feet of reservoir storage capacity may at some future date mean the difference between a crop or a crop failure.

CONSERVATION PROGRAM and BENEFITS

Loss in reservoir capacity and erosion of agricultural lands in the watershed indicate the need for general application of conservation practices.

The following practices should be applied in the Cold Springs watershed not only to reduce the rate of sedimentation but also to stabilize the agricultural economy.

On Class II land in wheat and summer fallow, which is about 20% of the watershed, conservation practices should include stubble mulching, contour seeding and tillage, and cloddy fallow. Rotations should include 4 years or more in alfalfa-grass, 10 years or less in grain-fallow.

Recommended conservation practices for Class II and III lands are similar, except that on Class III land the additional practice of contour strip cropping is recommended.

On Class IV land in wheat and summer fallow the rotation should be one of 4 years or more in alfalfa-grass or grass and 6 years or less in grain-fallow.

Land in capability Classes VI and VII, now in cultivation, should be permanently seeded to grass or other adaptable cover.

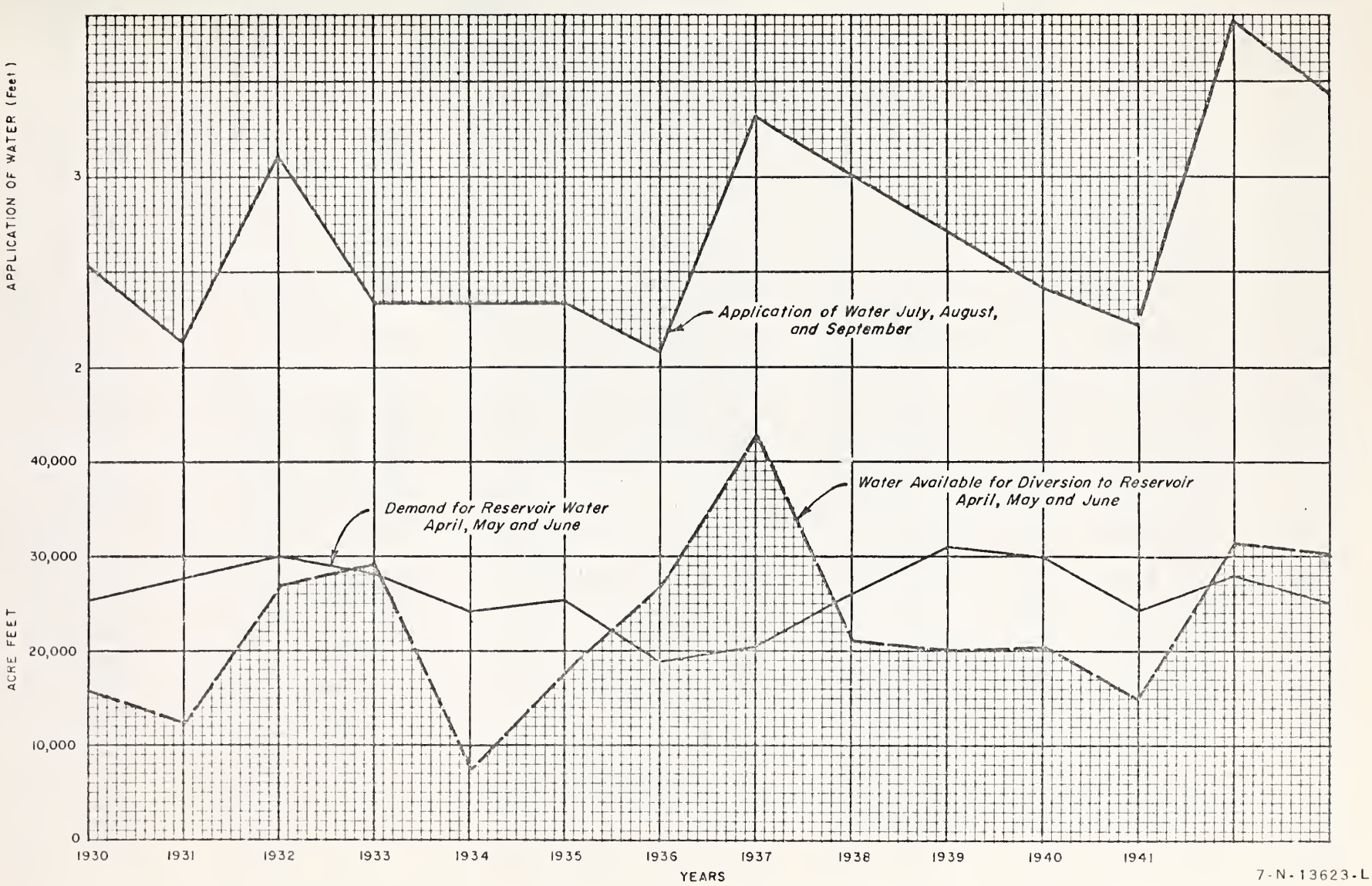


Figure 3. Relation of the amount of water available for diversion from the Umatilla River to Cold Springs Reservoir in April, May and June, to amount available for irrigation in July, August and September.

Some of the field waterways that extend upward toward the plateau surface from the main streams erode when cultivation is carried on along their sides or bottoms. These waterways should be plowed in, shaped and seeded to a grass-legume cover.

It is estimated that each year some 23,850 acres will require the proper utilization of stubble mulch and contour cross-slope tillage, and that about 4,615 acres should be seeded in rotation to grasses and legumes. These practices will require the farm operators to expend approximately $290,000 annually.

About 3,950 acres permanently seeded to grass, 95 miles of grassed waterways, and 10,000 acres of strip cropping will have a one-time cost of about $170,000.

Benefits of a conservation program will be twofold. A substantial reduction in reservoir sedimentation can be expected. Measurements on nonconservation farms and farms on which conservation measures have recently been established show a reduction in soil loss of more than 50 percent on the conservation farms under severe climatic conditions. After the organic matter has been restored to the topsoil, it is expected that the reduction in soil loss will be appreciably greater.

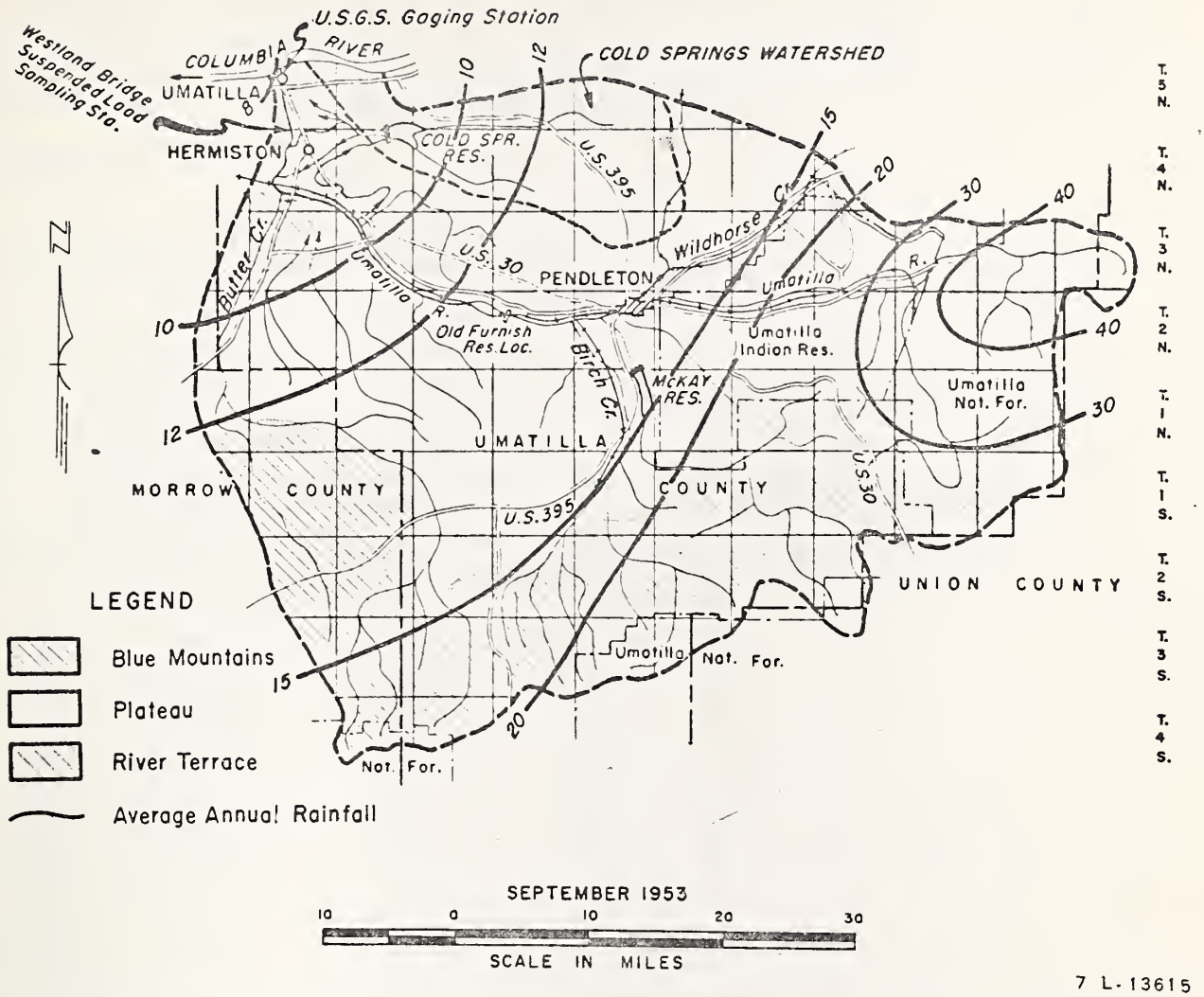
Benefits from maintenance of crop yields through conservation farming have been calculated for the Walla Walla watershed. These calculations were made in connection with a flood control survey of the Walla Walla River watershed by the U. S. Department of Agriculture. It was found in this adjacent watershed to the north, in a similar climatic zone and with similar soils and cropping practices, that the net average annual equivalent value of maintaining yields by a land treatment program would amount to 54 cents per acre per year on Class II land. The net average annual equivalent value to Class III land is 60 cents per acre and to Class IV land $2.52 per acre. By using these values for wheat-fallow land in Cold Springs watershed, the value of conservation farming over and above the costs of conservation measures applied would amount to about $67,000 per year.

DATA on SEDIMENTATION in the UMATILLA RIVER WATERSHED

The supplementary information on sedimentation in the Umatilla River watershed is given here because of the diversion of river flow into Cold Springs reservoir.

DESCRIPTION OF WATERSHED

The Umatilla River watershed drains an area of 2,290 square miles before entering the Columbia River just below McNary Dam. Map 8 shows that most of the watershed is within Umatilla County, with small portions in Morrow and Union Counties. The principal tributaries are Meacham Creek, McKay Creek, Wildhorse Creek, Birch Creek and Butter Creek. Elevations range from about 300 feet at the mouth of the river to approximately 5,000 feet in the Blue Mountains.



Map 8. The physiographic zones and average annual rainfall of the Umatilla River Watershed.

The west slope of the Blue Mountains consists of a maturely dissected monoclinal upland. The old and gently sloping upland surface, where preserved, is smoothly undulating. Canyons are cut from 1,000 to 1,500 feet below the ridges and the canyon walls expose stratified stair-like basalt flows totaling at least 2,000 feet in thickness. The soils are shallow to moderately deep and support open grassland at lower elevations and timber, predominately ponderosa pine, at higher elevations.

The rolling to hilly plateau declining in elevation toward the northwest and the river terraces near the river mouth have been described in connection with the Cold Springs watershed. The plateau surface in the eastern part of the watershed is devoted to wheat and fallow, or to wheat and peas in the narrow foothill zone where precipitation is greater than 15 inches per year. Isohyets of annual rainfall are shown on Map 8 with the approximate area

covered by the physiographic zones. The west and southwestern part of the watershed is largely grassland. Watershed protection in the headwater timbered area is afforded by the Umatilla National Forest.

The average annual runoff of the Umatilla River at the Umatilla USGS gaging station, between 1928 and 1949, has been 307,214 acre-feet. The range has been between 123,600 acre-feet and 679,800 acre-feet. These volumes exclude diversion for irrigation above the gaging station.

SUSPENDED LOAD DATA

Data on the sediment load carried by various streams in the Columbia Basin is needed for the purpose of planning a comprehensive agricultural program for the Columbia Basin. On the Umatilla River, a station at Hermiston was selected because of its proximity to the office of the West Umatilla Soil Conservation District where personnel is available. Although the USGS gaging station is near the town of Umatilla, about 3 miles below Westland Bridge where the sediment samples were taken, no tributaries are between the two points. Westland Bridge is located in Sec. 4, T. 4 N., R. 28 E. Samples were taken with a DH-48 suspended load hand sampler. This sampler was weighted so that it would not drift downstream with the current and a fin was attached in

DATE 1951	TIME	DISCHARGE C F S	SURFACE (PPM)	DEPTH INTEGRATED (PPM)
3/30	11:10 A.M.	1764	90	139
4/2	1:20 P.M.	1118	0	135
4/4	2:15 P.M.	1572	174	240
4/6	9:40 A.M.	2440	370	380
4/9	1:35 P.M.	1900	153	190
4/11	11:10 A.M.	1385	101	130
4/13	2:05 P.M.	1016	83	98
4/16	11:40 A.M.	1066	139	149
4/18	9:10 A.M.	887	148	129
4/20	10:00 A.M.	674	111	116
4/23	9:25 A.M.	378	96	100
4/25	9:25 A.M.	171	84	88
4/27	10:00 A.M.	100	79	84
4/30	10:30 A.M.	720	112	116
5/2	1:15 P.M.	500	94	97
5/4	9:30 A.M.	318	66	60
10/31	11:15 A.M.	255		70
11/2	9:00 A.M.	184	40	58
11/5	8:45 A.M.	167	51	30
11/7	9:45 A.M.	155	47	30
11/9	9:15 A.M.	151	89	63 (CONTAINED ORGANIC MATTER)
11/14	2:15 P.M.	189	34	36
11/16	8:40 A.M.	324	46	52
11/19	8:30 A.M.	260	29	38
11/21	8:30 A.M.	245	38	45
11/26	8:30 A.M.	235	37	28
11/28	8:30 A.M.	230	71	82
11/30	8:30 A.M.	363	60	94 (CONTAINED TWIGS)
12/3	8:30 A.M.	760	204	195
12/5		638	90	98
12/7		510	52	59
12/10	9:00 A.M.	369	TRACE	26
12/12	8:30 A.M.	294	28	22
12/14		250	54	17
12/17		220	25	21
12/19		220	37	22
12/21		245	58	22
12/31		430	39	(BROKEN IN SHIPMENT)

Table 5. Suspended sediment load data, Umatilla River at Westland Bridge near Hermiston, Oregon 1951-52.

DATE 1952	TIME	DISCHARGE C F S	SURFACE (PPM)	DEPTH INTEGRATED (PPM)
1/2	8:30 A.M.	356	28	(BROKEN IN SHIPMENT)
1/4		270	35	24
1/7		395	31	30
1/9		369	28	22
1/11		330	27	27
1/14		270	97	95
1/16		265	24	26
1/18		230	54	33
1/21		250	14	22 (BOTTLE RECEIVED HALF FULL)
1/23		230	36	42
1/25		220	25	27
1/28		638	1950	(BROKEN IN SHIPMENT)
1/30		920	685	720
2/1	8:30 A.M.	1540		4540 (BROKEN IN SHIPMENT)
2/4		1764	2200	2798
2/6		1940	819	1112
2/8		1310	344	480
2/11		780	210	230
2/13		665	96	94
2/15	9:00 A.M.	556	58	69
2/18	8:30 A.M.	430	31	67
2/20		362	41	52
2/25		270	29	24
2/29		60	21	32
3/3	8:30 A.M.	755	10	22
3/5		250	12	21
3/7		230	30	10
3/10		250	34	25
3/12		454	136	136
3/14		409	27	46
3/17		337	21	13
3/19	9:00 A.M.	270	39	24
3/21	8:30 A.M.	245	22	16
3/24		250	19	18
3/26		3052	4080	4030
3/27		3556	2040	2295
3/28		2863	1600	1549
3/31		1460	639	665
4/1	8:30 A.M.	1198	173	358
4/2		980	207	230
4/3		821	203	227
4/4		720	114	65
4/7		2905	615	1040
4/8		3982	1442	1340 (SAMPLE # REPEATED)
4/9		1900	545	770
4/10		1212	262	362
4/11		1040	200	210
4/14		1170	243	250
4/16		2760	640	784
4/18		1524	274	320
4/21		1604	320	(BROKEN IN SHIPMENT)

Table 5.(con't.) Sediment load data, 1952.

order to keep it headed into the stream flow. Both surface and depth integrated samples were obtained in order to determine the relationship between the concentration of the two samples. This was done in part to make greater application of data from older sampling programs, when samples were taken only from the surface of the flow. Table 5 shows the discharge and sediment concentration during the period of record, which extended from March 31 to May 4, 1951 and from October 31 to April 26, 1952. From these data, and assuming an average weight of 70 lbs. of sediment per cubic foot, the sediment rating curve, Figure 4, *page 24*, was plotted. From the USGS gaging station records at Umatilla, a flow duration curve was also plotted, Figure 5, *page 25*. By the use of these two curves it was determined that the volume of suspended load carried by the Umatilla River amounts to about 550 acre-feet on the average annually. This represents a rate of suspended load transportation of about 0.24 acre-feet per square mile from the 2,290 square mile watershed above.

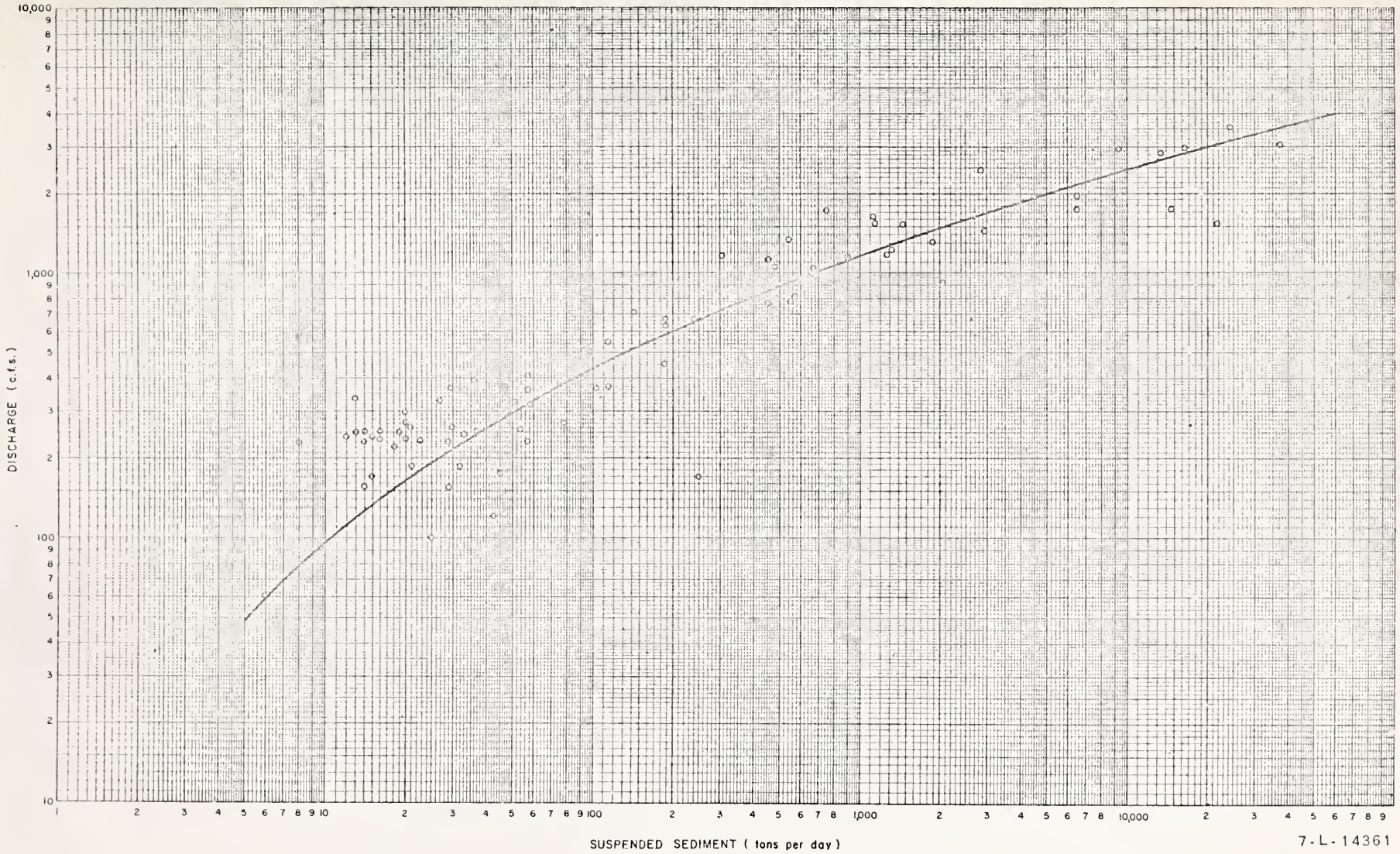


Figure 4. Sediment rating curve, Umatilla River at Westland Bridge near Hermiston, Oregon Mar. 30, 1951-Apr. 14, 1951, Oct. 31, 1951-Apr. 25, 1952.

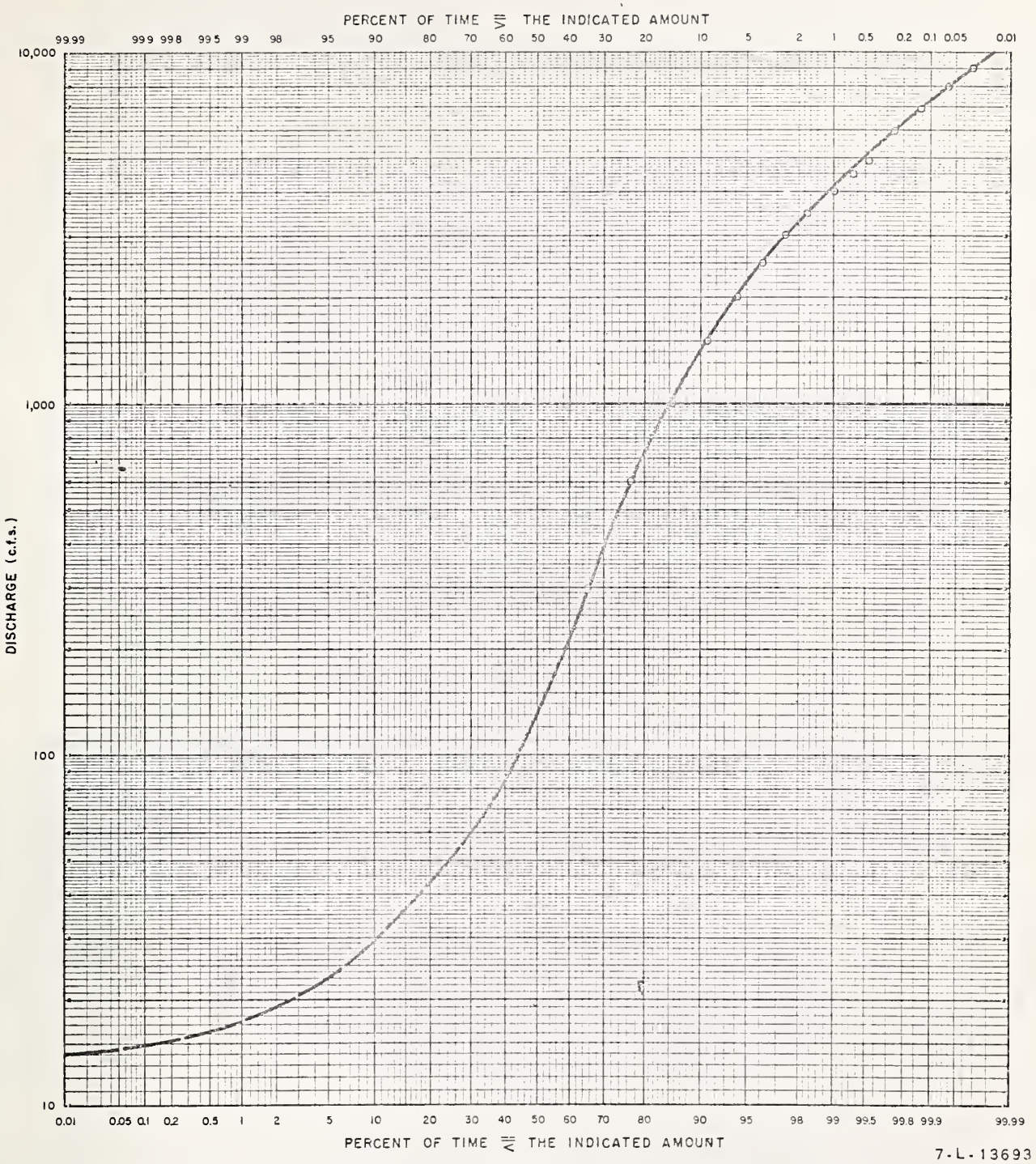


Figure 5. Flow duration curve, Umatilla River near Umatilla, Oregon 1909-1948.

The bedload volume is probably 10-20 percent of the suspended load volume. These data also show that sedimentation concentrations in the surface samples averaged 89 percent of the depth-integrated samples.

A major source of sediment in the Umatilla River watershed is reported to be Wildhorse Creek, which enters the river at Pendleton from the northeast. In early February 1952, during the runoff following a thaw, it was reported

that the sediment concentration amounted to about 9% of the peak flow of 1,800 cubic feet per second. This tributary consists largely of agricultural land of which a part is in the annual cropping zone of wheat and peas.

McKAY RESERVOIR

The McKay Reservoir was built by the Bureau of Reclamation to store water on McKay Creek for irrigation in the vicinity of Stanfield. It supplies water for the south division of the Umatilla Irrigation Project. The dam is an earth fill structure about 2,600 feet long and 160 feet in height above the streambed. The original storage capacity was about 73,000 acre-feet. The first water was impounded in October, 1926. About 90% of the watershed of 186 square miles is forest and grazing land in the Blue Mountains. A maximum of 10% is wheat and fallow land.

A reconnaissance sedimentation survey of the reservoir was made by the Soil Conservation Service on July 11, 1946. It was found that about 263 acre feet of sediment were deposited during a period of 19.75 years. This is equivalent to 13.3 acre-feet of deposition per year and about .07 acre-foot per square mile of watershed. It is believed that the measured amount is a minimum value because of adverse weather conditions at the time of survey. However, the rate corresponds favorably with data on suspended load measurements from other streams issuing from the Blue Mountains.

CONCLUSIONS

Sediment accumulation in Cold Springs Reservoir is causing reduction in the average annual amount of water available for irrigation. Application of conservation measures in the tributary watershed will not only protect the reservoir storage capacity but will be of substantial benefit to the farms on which the measures were applied. Sedimentation continuing in the future as in the past will eventually create a serious water shortage during low runoff years.

Operation of the headgate of the diversion canal for the purpose of bypassing sediment-charged flows during periods of thaw would reduce canal maintenance and reservoir deposition from this source. It is apparently necessary to keep the gates open at practically all times during the winter and spring months, however, because of limited canal capacity and limited periods of flood flow.

Data has also been presented on the suspended sediment load of the Umatilla River. The watershed above covers a wide range of land use and cover conditions. Further studies will be required to determine the significance of erosion and sediment damages within this larger watershed. The Cold Springs investigation points to some of the soil and water conservation problems in the area.